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1. Your reference	X262	
2. Patent application number *(The Patent Office will fill in this part)*	20 FEB 1997	9703512.5
3. Full name, address and postcode of the or of each applicant *(underline all surnames)*	Xaar Limited Science Park Milton Road Cambridge CB4 4FD	
Patents ADP number *(if you know it)*		
If the applicant is a corporate body, give the country/state of its incorporation	UK	05605894002
4. Title of the invention	Printer and Method of Operation	
5. Name of your agent *(if you have one)*		
"Address for service" in the United Kingdom to which all correspondence should be sent *(including the postcode)*	~~Ian Hartwell~~ ~~Xaar Limited~~ ~~Science Park~~ ~~Milton Road~~ ~~Cambridge~~ ~~CB4 4FD~~	MATHYS & SQUIRE 100 GRAYS INN ROAD LONDON WC1X 8AL
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7. If this application is divided or otherwise derived from an earlier UK application, give the number and the filing date of the earlier application	Number of earlier application	Date of filing *(day / month / year)*
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Claim(s)	5
Abstract	----- 7
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Translations of priority documents	-----
Statement of inventorship and right to grant of a patent *(Patents Form 7/77)*	-----
Request for preliminary examination and search *(Patents Form 9/77)*	-----
Request for substantive examination *(Patents Form 10/77)*	-----
Any other documents *(please specify)*	-----

11. I/We request the grant of a patent on the basis of this application.

Signature I. Hartwell Date 19/2/97

12. Name and daytime telephone number of person to contact in the United Kingdom — Ian Hartwell (01223) 423663

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PRINTER AND METHOD OF OPERATION

The present invention relates to printers comprising a printhead for printing on a substrate and comprising an array of printing elements arranged for printing a swath of greater width than that printed by a single printing element when the substrate and printhead are moved relative to one another. A single dot is printed by each print element - which may be an inkjet nozzle, a wire dot actuator or any similar device as are well known in the art - with the swath as a whole forming a so-called "dot matrix" which is used to represent images on the substrate. The invention also relates to a copier incorporating such a printer.

The most widely used "dot matrix" printer configuration is the so-called "serial" printer in which a printhead mounted on a movable carriage is scanned across a substrate whilst printing, the substrate being indexed between successive print scans in a direction perpendicular to the scanning direction so as to allow printing on a further section of the substrate during the scan of the printhead that follows. The speed at which such a printer configuration can operate is limited by dynamic factors, for example the maximum acceleration to which a printhead may be subjected when changing direction at the end of a scan and yet still print satisfactorily.

In another known "dot matrix" printer configuration, the printhead remains stationary whilst the substrate - which is attached to a rotating drum - is scanned past. Since the printhead is only moved (by an index distance of a swath width) once every revolution of the drum, a much higher print rate can be achieved before the dynamic limits of the printhead are reached. However, this also means that the print rate remains the same regardless of the size of paper attached to the drum: as will be evident from a comparison of figures 1(a) and (b) which show a printer comprising an indexable printhead 1 and a rotatable drum 2, the same number of drum revolutions - and thus the same amount of time - will be required to print the

"A3" size sheet shown in figure 1(a) as will be required to print the "A4" size sheet shown in figure 1(b). This is despite the fact that the distance 4 by which latter extends around the drum is half the distance 3 occupied by the "A3" sheet, the axial distance 6 covered by each sheet being the same in both cases.

The present invention avoids this discrepancy whilst retaining the advantages of higher operating speed associated with the drum printer configuration.

Accordingly, the present invention consists in a method of printing on a substrate using a printer, the printer comprising a printhead for printing on the substrate and means for moving the substrate relative to the printhead along a first path; the printhead comprising an array of printing elements arranged for printing a swath of greater width than that printed by a single printing element when the substrate is moved along said first path relative to the printhead; the method including oscillating the substrate relative to the printhead along said first path whilst moving the printhead along a second path arranged at an angle to said first path.

According to the present invention, an oscillating means is employed for moving the substrate. The magnitude of the oscillation can be varied such that - unlike a drum printer - the movement of the substrate transport means can be adapted to the width of the substrate to be printed. Thus with reference to the "drum printer" example of figure 1, the amount of time required to print an A4 sheet need only be half that required to print an A3 sheet having twice the width.

The invention also comprises a corresponding printer and a method and apparatus for scanning an image from a first substrate and printing said image on a second substrate. Further advantageous embodiments of the invention are given in the dependent claims and description.

The invention will now be described by way of reference to the following diagrams, of which:

Figure 1(a) and (b) are schematic views of a conventional "drum printer" as discussed above;

Figures 2(a) and 2(b) are perspective and schematic side views of a printer according to the present invention;

Figure 3 is a plan view of the printer shown in figures 2(a) and (b);

Figure 4 is a plan view corresponding to figure 3 and illustrating a further step in the method according to the present invention;

Figures 5(a) and (b) show the operation of the printer of figures 2-4 with varying paper widths;

Figures 6 (a) - (c) illustrate various printhead layouts falling within the present invention;

Figures 7 (a) - (c) illustrate further printhead layouts falling within the present invention;

Figure 8 illustrates a copier incorporating the present invention.

Figures 2(a) and (b) illustrate a first embodiment of a printer according to the present invention. A substrate - for example a sheet of paper 12 - is carried by a belt 14 supported for oscillatory movement (as indicated by arrows 16) by rollers 18, one at least of which may be controllably driven e.g. by a stepping motor. Located above the mid-point of the belt length is the printhead 20, supported for movement along a linear path (indicated by arrow 24) perpendicular to the direction of substrate movement 16, for example by guide rails 22.

In the example shown, the printhead 20 comprises a linear print element array arranged parallel to the direction of movement of the printhead and perpendicular to the direction of movement of the substrate relative to the printhead. This need not be the case, however: as long as the formation of a dot matrix is ensured by the printing a swath of greater width than that printed by a single printing element when the substrate is moved along said first path relative to the printhead, the array of print elements may be arranged at any non-zero angle to the direction of movement of the substrate relative to the printhead (such angling of

the array may be desirable on grounds of increasing print resolution). Nor does the array need to be linear.

By means of the belt, the paper is moved from to right to left as shown in figure 3 (from location A shown in solid lines to location B shown in dotted lines) and passes underneath the printhead 20 which prints a first swath 26. The printhead is then indexed by a swath width in direction 24 to the position shown in figure 4, whereupon the paper is moved from left to right, back to position A, passing underneath the printhead which prints a second swath 28 abutting the first swath 26. In printing the second swath, it will generally be the case that at least one of the same printing elements employed in printing the first swath will be used to print this second swath. Further indexing of the printhead 20 together with further oscillations of the paper allow further swaths to be printed, at the end of which the paper is released from the belt and into an output tray 30 and a fresh sheet of paper is fed onto the belt from an input stack 32.

The advantage of the present invention over known printer configurations will now be explained by way of example with reference to figure 5, whereby figure 5a represents the layout of a printer when printing an "A3" size sheet of height H and width W and figure 5b represents the layout of the same printer when printing an "A4" size sheet also of height H but of width W/2. It will be appreciated that the rate (V in mm/s) at which the printhead can print a swath on the passing substrate will be the same in both instances, V being determined by the mechanism of the printhead itself. However, it will be evident from the figures that the necessary amplitude O of oscillation of the substrate relative to the printhead will vary between the two arrangements, O being substantially equal to W in figure 5(a) and to W/2 in figure 5(b). The time required for each scan is consequently W/V and W/(2V) respectively. It will also be clear from the figures that the number of scans N required to fill a page will be the same for each layout, being proportional to the ration of printhead swath width S to page height H. Thus, in contrast to the drum printer arrangments discussed with regard to figure 1, the time taken to print an

"A4" sheet - approximately equal to N.W/(2V) - will be substantially half the time required to print an "A3" sheet of double the width, namely N.W/V. Such a time saving becomes particularly significant in the case of long print runs of the smaller paper size.

It should be noted that printhead movement is not necessarily restricted to jumps of a swath width following each scan of the substrate: it may be possible to move the printhead continuously whilst scanning the substrate, resulting in the printing of lines at an angle to the substrate scan direction 16 which combine to fill the page. Alternatively or in addition, the direction of printhead movement may be arranged at an angle other than 90° to the substrate scanning direction. The printhead can be moved by any of the means conventionally used in printers e.g. toothed belt or lead screw, which in turn may be driven by a stepping motor. It will be appreciated that a variety of other means generally known in the printer art can also be used to move the substrate.

The present invention is amenable to use with a variety of configurations of the printhead, a number of which are shown schematically in figures 6 and 7. Figure 6(a) shows a printhead 20 comprising four sections of equal swath width, each of which prints a different colour (e.g. the three subtractive primary colours cyan, magenta, yellow, together with black, indicated by "C", "M", "Y" and "K" in the figures). It will be understood that, unlike the embodiment of figures 2-4 employing a monochrome printhead, such a multi-colour printhead is indexed following each pass of the substrate only by an amount equal to the width of swath printed by a single colour section. Figure 6(b) illustrates an arrangement which utilises two printheads of the kind shown in figure 6(a), each printing a respective half of the substrate, and which consequently will have twice the potential throughput of the arrangement of figure 6(a). Similarly, the arrangement of figure 6(c), having three of the printheads of the kind shown in figure 6(a), will have a correspondingly three times greater potential throughput.

An increase in throughput can also be achieved by using two (or more) guide rail assemblies, each supporting one or more printheads , which are mounted in parallel and spaced in the direction of oscillatory movement of the belt. Since respective halves of the substrate are thereby printed simultaneously, the amount by which the belt need oscillate is correspondingly halved.

In addition or as an alternative to increased throughput, an increase in print resolution may be desirable. Figure 7(a) illustrates an arrangement in which the printhead 20 comprises two units 20' and 20" of the kind shown in figure 6(a) and having a given print resolution equivalent to a pitch between printed dots of P. The units 20' and 20" are offset relative to one another in the direction 24 of movement of printhead by P/2 and consequently print a swath of dots at a pitch P/2 i.e. at twice the resolution of the single unit shown in figure 6(a). The throughput-enhancing principles behind figures 6(b) and (c) are also applicable to this arrangement, giving the configurations shown in figures 7(b) and (c) respectively. As an alternative to the above, resolution may be increased by interleaving the rows of dots printed in one scan of the substrate with those rows printed in the course of one or more successive scans of the printhead. Interleaving per se is well known in the context of serial and drum printers, as are many variations thereon aimed at improving the resulting print quality, and consequently will not be discussed in further detail here. It will be appreciated that all such interleaving strategies are applicable to the present invention.

Figure 8 illustrates the present invention as embodied in a copier, with those elements common to earlier figures having the same reference numbers. A belt 14 not only oscillates the substrate 12 relative to the printhead 20 but also moves the original document 40 which is to be copied past a scanner head 42. Signals corresponding to the image on the document 40 passing the scanner 40 are sent via processing circuitry (not shown) to the printhead 20 which prints a corresponding image on the substrate 12. It will be appreciated that the use of a single (not necessarily continuous) belt to transport both original 40 and copy 14

reduces complexity and may allow the scanner signals to be sent directly for printing at the printhead, avoiding the need for buffer memory. It will be evident that the use of a continuous belt 14 as per figure 8 gives a particularly compact construction: original documents may be fed onto the belt 14 from a feeder 44 and removed from the belt after copying by a further sheet feed mechanism 46 for return to the skip 44. Similar efficiency savings may be achieved by coupling the scanner head and the printhead such that they can be moved by a single actuator.

In the examples given above, the substrate is moved relative to the printhead along a linear path, preferably by means of a belt. This allows conventional linear paper handling technology - as used in photocopiers for example - to be employed for feeding paper to and from the printer mechanism. Furthermore, in the particular case of belt conveyors, paper attachment can be achieved by simple, conventional mechanisms such as vacuum or electrostatics. A belt system also has low inertia - an important consideration in a rapidly oscillating system - and can easily be provided with encoding marks (either on the paper supporting surface or the surface opposite thereto) to ensure registration of belt movement and printhead operation. Apertures can also be formed in a belt to allow maintenance of the printhead from the underside of the belt : this may entail the use of multiple apertures and/or multiple stations for the conventional steps of purging, wiping, capping etc. However, this is not to exclude other substrate conveyor means such as rollers or an oscillating rather than a rotating drum from the scope of the present invention.

It will be evident that the present invention is applicable to any kind of printer in which the printhead has an array of printing elements. Such printheads are known generically as "dot matrix" printheads and include inkjet printheads, including thermal and piezoelectric actuation and wire dot matrix printhead. The advantages are most evident in inkjet printheads, however, which are particularly prone to failure due to dynamic factors, in particular due to pressure waves generated in the ink.

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CLAIMS

1. Method of printing on a substrate using a printer, the printer comprising a printhead for printing on the substrate and means for moving the substrate relative to the printhead along a first path; the printhead comprising an array of printing elements arranged for printing a swath of greater width than that printed by a single printing element when the substrate is moved along said first path relative to the printhead;

the method including oscillating the substrate relative to the printhead along said first path whilst moving the printhead along a second path arranged at an angle to said first path.

2. Printer comprising a printhead for printing on a substrate and means for moving the substrate relative to the printhead along a first path; the printhead comprising an array of printing elements arranged for printing a swath of greater width than that printed by a single printing element when the substrate is moved along said first path relative to the printhead;

the printer including means for oscillating the substrate relative to the printhead along said first path and means for moving the printhead along a second path arranged at an angle to said first path.

3. Method or apparatus according to any previous claim, wherein said first path is linear.

4. Method or apparatus according to claim 3, wherein the substrate is moved along the first path by means of a belt.

5. Method or apparatus according to any previous claim, wherein said second path is perpendicular to said first path.

6. Method or apparatus according to any previous claim, wherein said second path is linear.

7. Method or apparatus according to any previous claim, wherein the array of printing elements is linear.

8. Method or apparatus according to claim 7, wherein the linear array of printing elements is arranged parallel to the second path.

9. Method or apparatus according to any previous claim, wherein the printhead moves along the second path in a continuous manner.

10. Method or apparatus according to any previous claim, wherein the printhead moves along the second path in a stepwise manner.

11. Method or apparatus according to any previous claim, wherein each printhead comprises a plurality of groups of printing elements, the printing elements of each group being arranged into a linear sub-array, the plurality of sub-arrays being arranged along a straight line.

12. Method or apparatus according to claim 11, wherein printing elements belonging to the same group print the same colour dot on the substrate, whereby not all groups print the same colour.

13. Method or apparatus according to claim 12, wherein each group prints a different colour of dot on the substrate.

14. Method or apparatus according to any previous claim, wherein the printer comprises a plurality of printheads spaced along the second path and moveable in synchronism along said second path thereby to print swaths on respective sections of the substrate.

15. Method or apparatus according to any previous claim, wherein each printhead comprises a plurality of groups of printing elements, the printing elements of each group being arranged into a plurality of linear sub-arrays, the plurality of sub-arrays being arranged in parallel.

16. Method or apparatus according to claim 15, wherein the printing elements of one of said sub-arrays place dots on the substrate in between dots placed on the substrate by another of said sub-arrays.

17. Method or apparatus according to claim 16, wherein two like sub-arrays are offset relative to one another in the second direction by half the pitch between successive printing elements in each sub-array.

18. Method or apparatus according to any previous claim, wherein the substrate is moved along the first path in a first direction, the printhead thereby printing a first swath on the substrate, thereafter moving the printhead along the second path by an amount equivalent to a non-integer multiple of the pitch between successive printing elements in the array of printing elements, and thereafter reversing the direction of movement of the substrate along the first path, the printhead thereby printing a second swath on the substrate that is interleaved with said first swath.

19. Method of scanning an image from a first substrate by means of a scanner and printing said image on a second substrate by means of a printer,

the scanner comprising a scanner head and means for moving the first substrate relative to the scanner head along a first path,

the printer comprising a printhead and means for moving the second substrate relative to the printhead along a second path, the printhead comprising an array of printing elements arranged for printing a swath of greater width than that printed by a single printing element when the substrate is moved along said second path relative to the printhead,

the method including oscillating the first substrate relative to the scanner head along said first path, thereby to scan a swath of said first substrate whilst moving the scanner head along a third path arranged at an angle to said first path,

and oscillating the second substrate relative to the printhead along said second path and moving the printhead along a fourth path arranged at an angle to said second path in synchronism with the oscillation of said first substrate and the movement of said scanner head respectively,

signals from said scanner head being employed to drive said printhead, thereby to copy an image from said first substrate to said second substrate.

20. Apparatus for scanning an image from a first substrate and printing said image on a second substrate, the apparatus comprising

a scanner comprising a scanner head, means for oscillating the first substrate relative to the scanner head along a first path, thereby to scan a swath of said first substrate, and means for moving the scanner head along a third path arranged at an angle to said first path;

a printer comprising a printhead, the printhead comprising an array of printing elements arranged for printing a swath of greater width than that printed by a single printing element when the substrate is moved along a second path relative to the printhead, means for oscillating the second substrate relative to the printhead along said second path, and means for moving the printhead along a fourth path arranged at an angle to said second path; and

means for driving said means for oscillating the first substrate and means for oscillating the second substrate in synchronism and for driving said means for moving the scanner head and means for moving the printhead in synchronism;

signals from said scanner head being employed to drive said printhead, thereby to copy an image from said first substrate to said second substrate.

21. Method or apparatus according to claim 19 or 20, wherein said first and third paths are linear.

22. Method or apparatus according to claim 21, wherein said first and third paths are parallel.

23. Method or apparatus according to any of claims 19 to 22, wherein a single means oscillates both the first and second substrates.

24. Method or apparatus according to claim 23, wherein said first and second substrates are moved by a single belt.

25. Method or apparatus according to claim 24, wherein said belt is continuous.

26. Method or apparatus according to any of claims 19 to 25, wherein a single means moves both the scanner head and the printhead.

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Fig. 1(a)

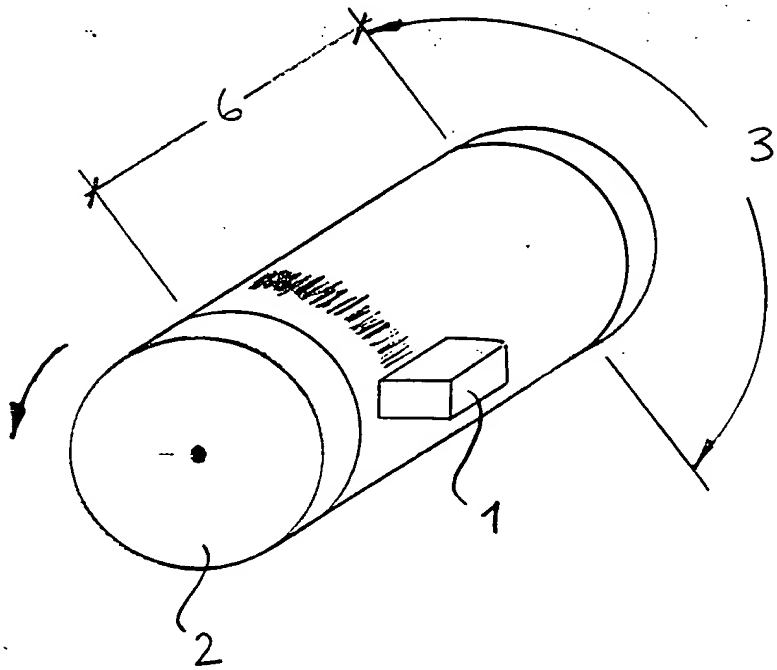

Fig. 1(b)

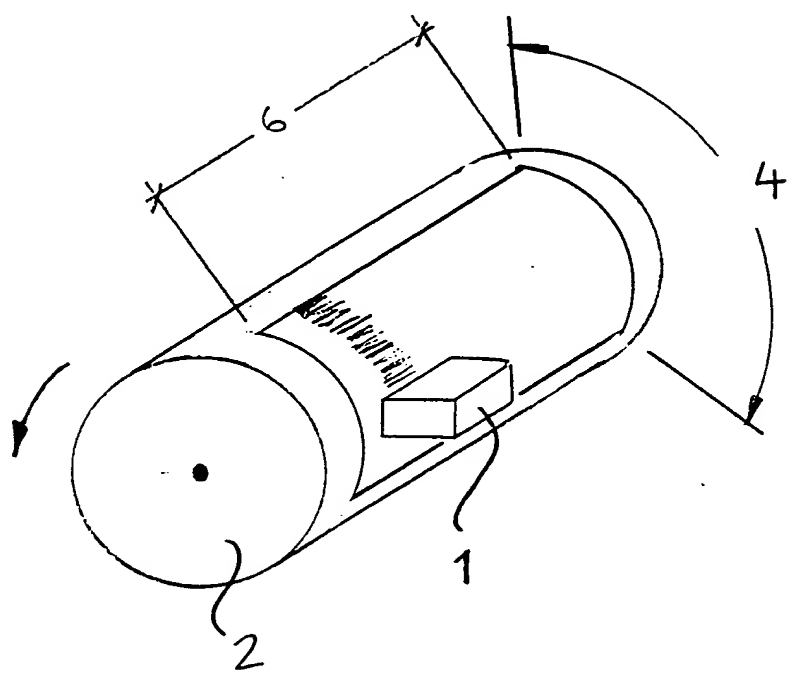

Figure 2(a)

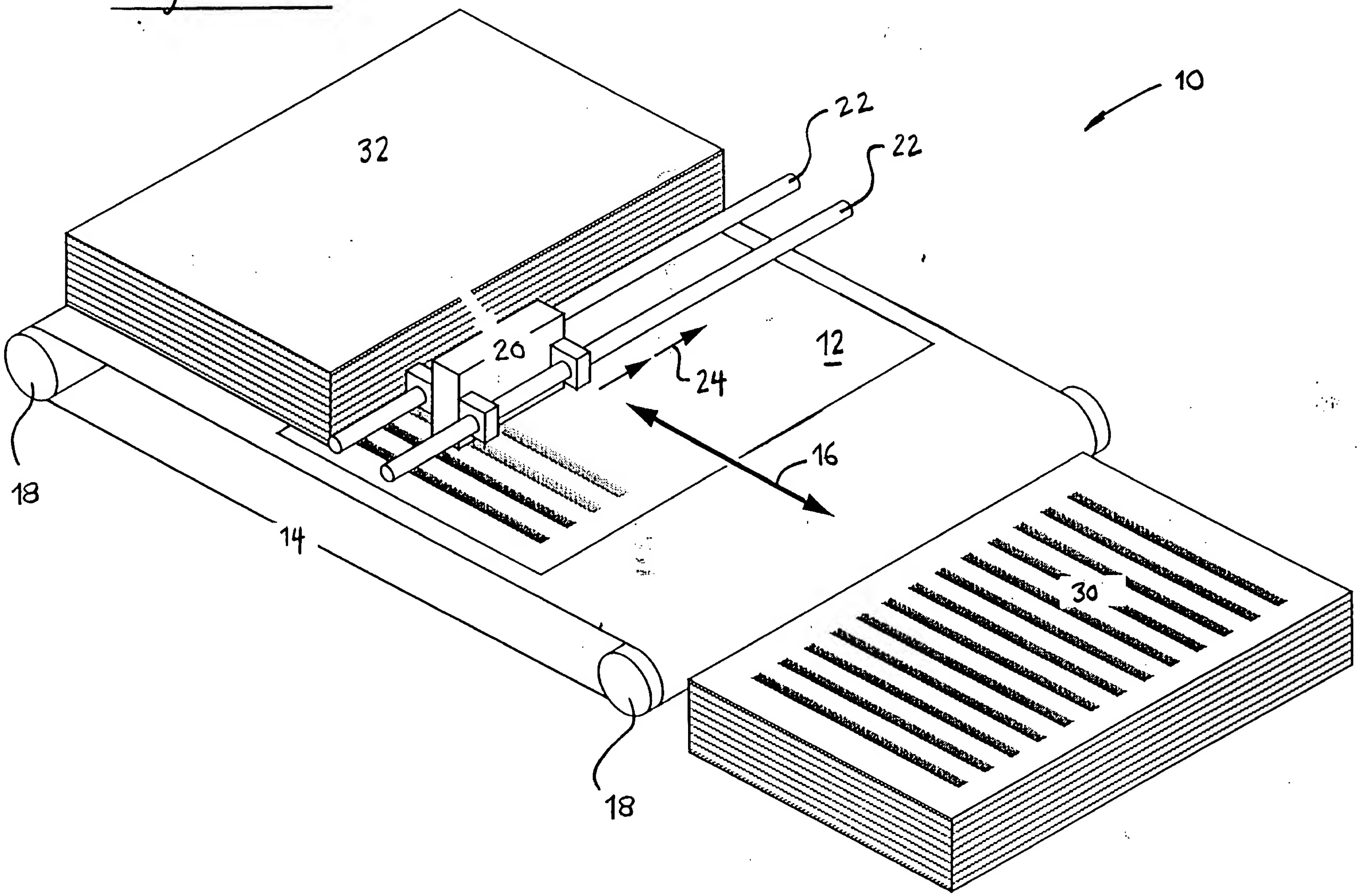

Figure 2(b)

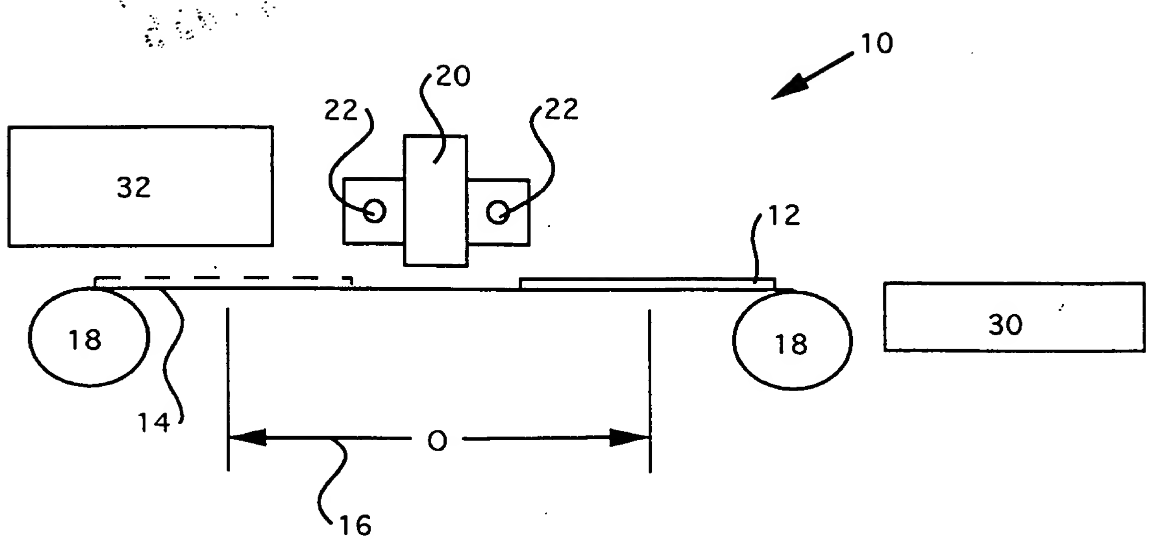

Figure 3

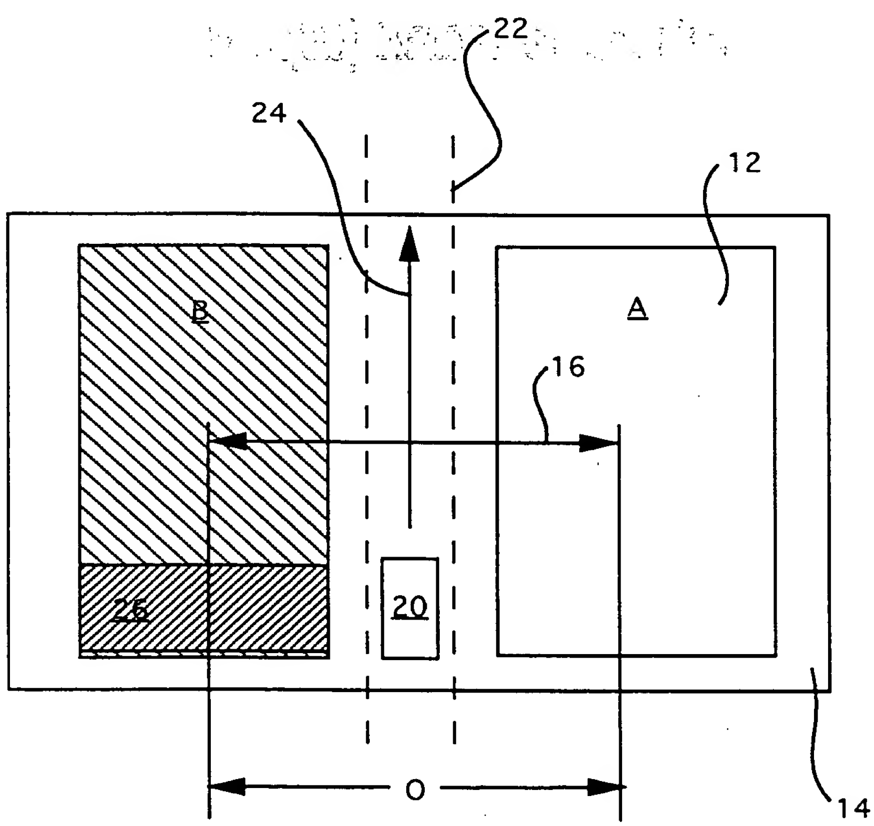

FIG. 4

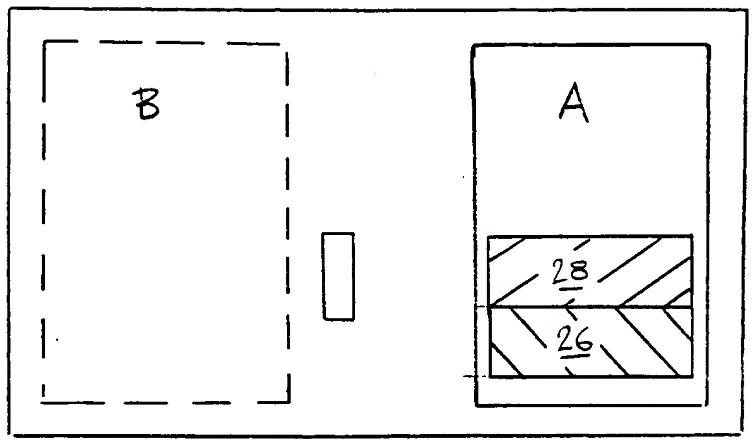

FIG. 5(a)

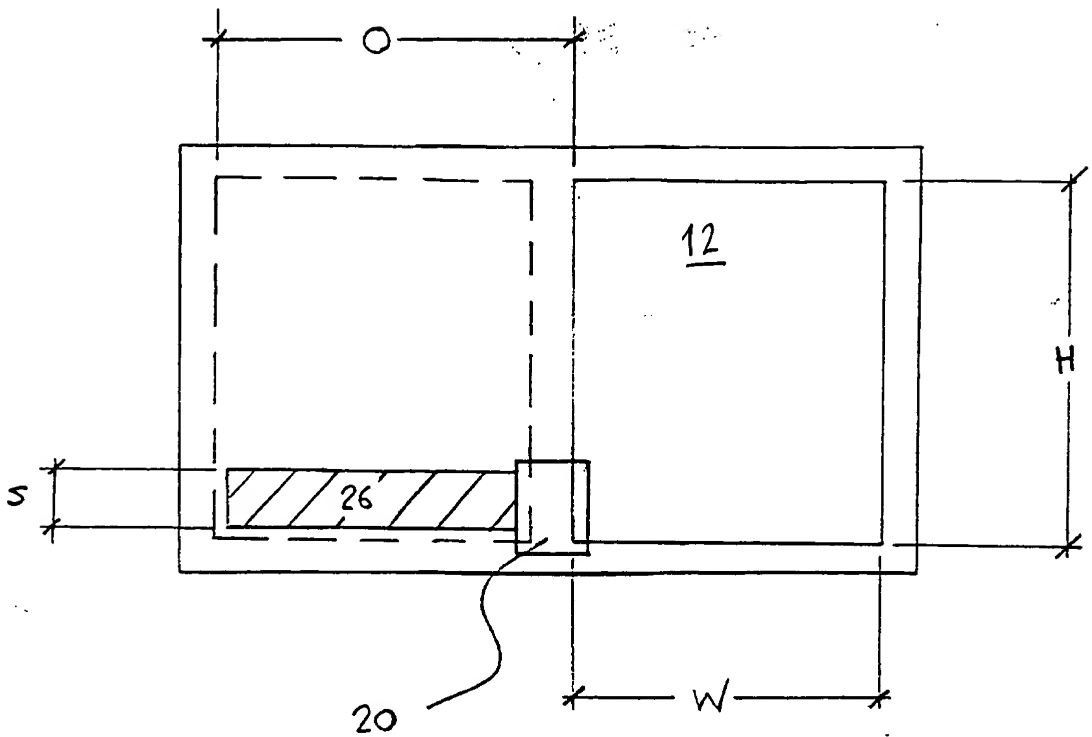

FIG. 5(b)

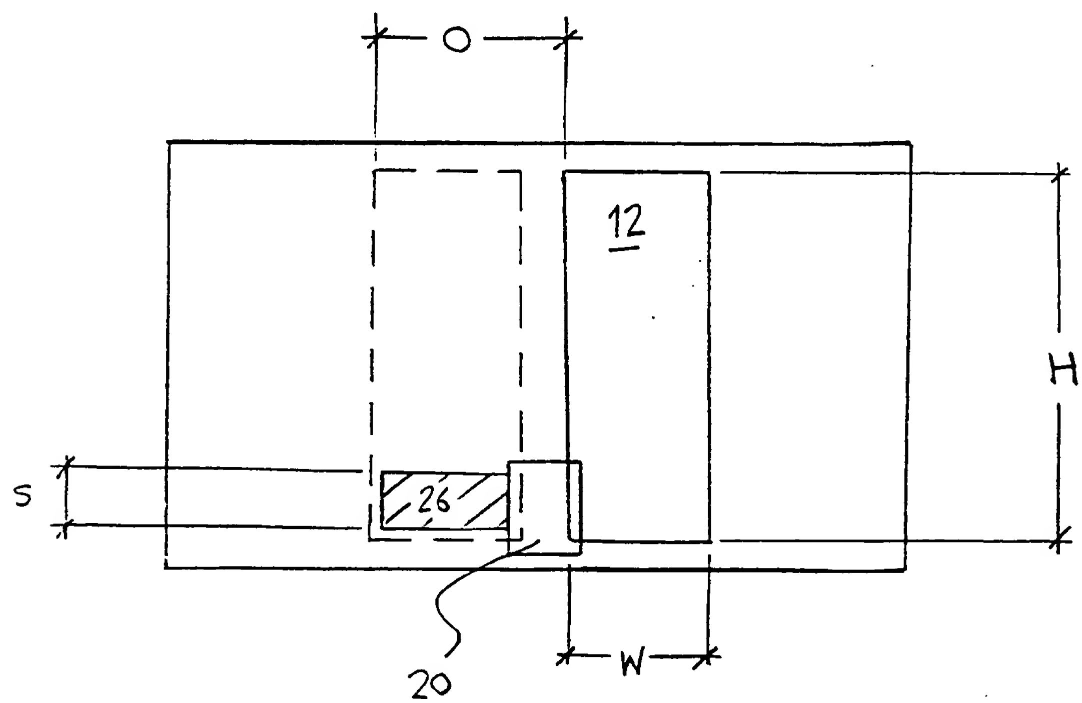

FIGURE 6

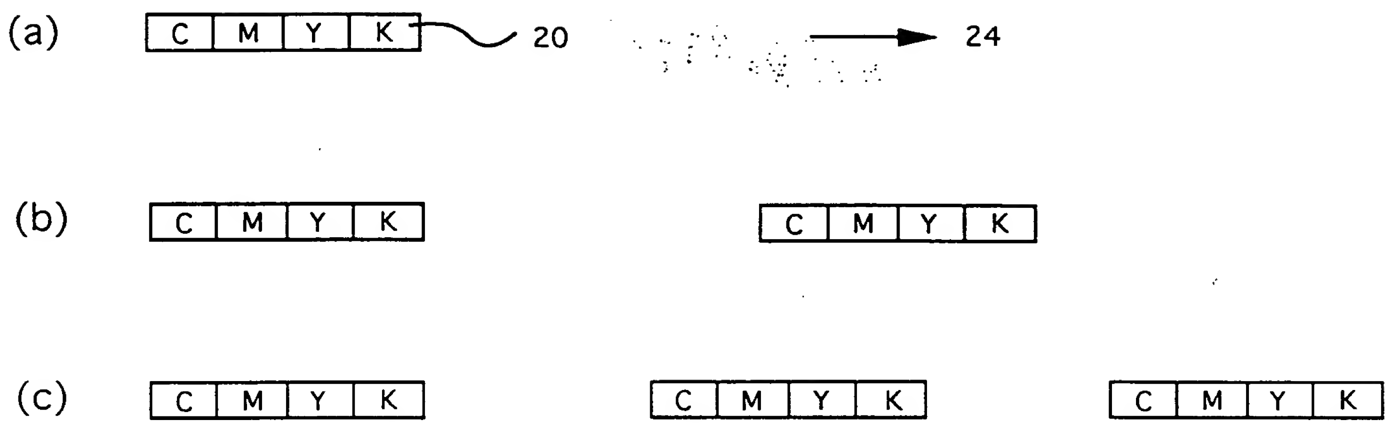

FIGURE 7

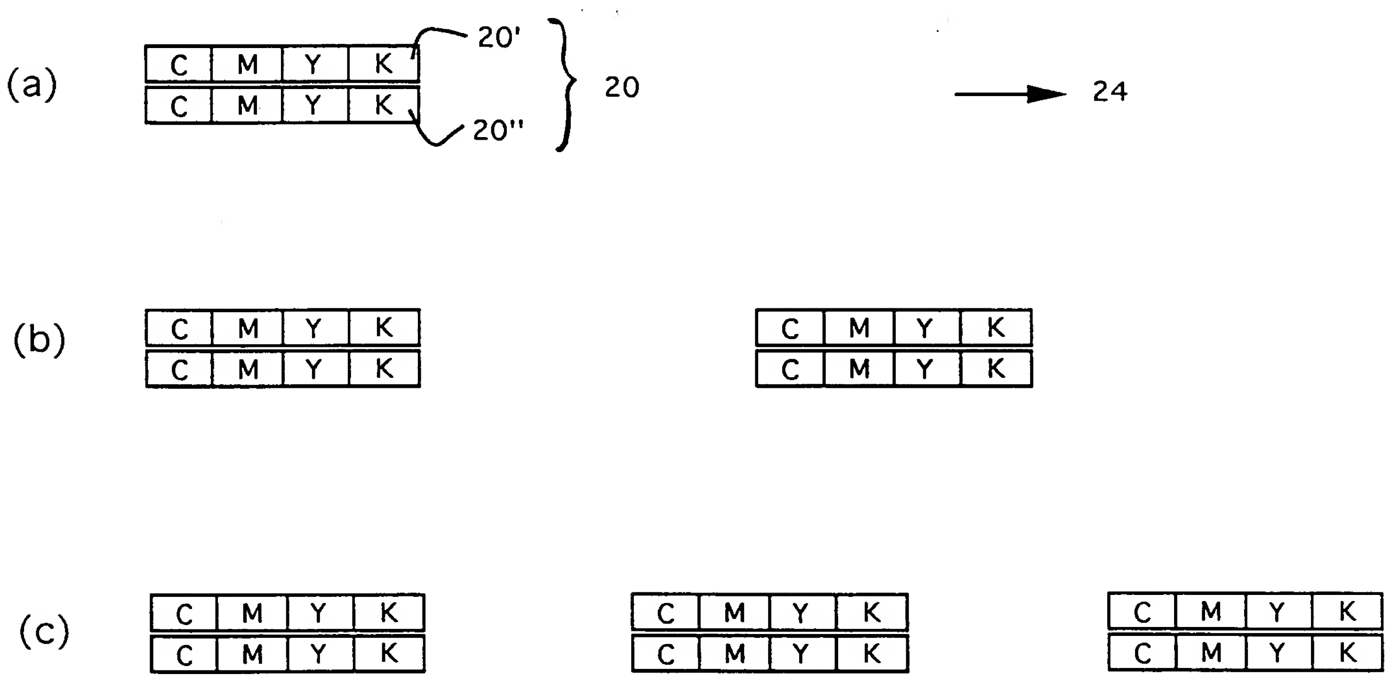

Figure 8